CHAPTER IV

SOURCE DEVELOPMENT

In selecting a source of water to be developed, the design engineer must determine that an adequate quantity of water exists for which a vested water right or permit to appropriate can be lawfully obtained and that the water which is to be delivered to the consumers will meet KDHE's PWS quality standards.

A. QUANTITY REQUIREMENTS

The quantity of water at the source shall be adequate to meet the projected maximum daily demand for the design period. Rights to the water must be obtained from DWR, which administers the Kansas Water Appropriation Act. A potential water user must make application to DWR in order to begin the process necessary to establish a water right (15). The time period for processing an application for a permit by DWR may be substantial. Processing time of one year or more is not unusual. Assistance in completing an application can be obtained from any of the DWR field offices. The DWR considers a water use projection for twenty years reasonable for determining the requested quantity of water on an application to appropriate for municipal water supply use.

It is illegal for a PWSS in Kansas to use water without holding a vested right or applying for and receiving a permit to appropriate water. Also, it is important to recognize that some parts of Kansas have no water available for new permits. In those areas, acquisition of an existing water right and obtaining approval to change one or more of the water right's features may be the only way to meet future water needs. Features associated with an existing water right that must not be changed without DWR approval include the type of water use, the point of diversion (e.g. location of intake structure in a reservoir, stream, or river), or the place of water use. An acceptable meter must be installed on each diversion works in accordance with DWR's specifications and maintained in a satisfactory condition and used to provide water use information required on the annual water use report.

Yield restrictions for the various water resources are as follows:

1. FLOWING SOURCES - Where water is drawn from a flowing stream, river, or spring, DWR flow records should confirm its availability to meet the maximum daily demand for the design period during a 50 year drought with all prior water rights considered. The occurrence of a 100 year flood should not impair the proposed PWSS facilities.

2. IMPOUNDMENTS - Reservoirs and lakes used for PWS must meet the drought and flood restrictions of flowing streams. The effective storage needed to provide the firm yield shall take into account evaporation, seepage, and siltation losses. KWO handles requests for water from federal reservoirs through their water marketing program. Also, DWR must approve all plans for construction of dams which impound more than 30 acre-ft (37,000 m^3).

3. WELLS - Proposed well installations should be based on pumping test and/or historical records of withdrawal where available. Rights for withdrawal of groundwater must be obtained from DWR similar to the procedure for surface waters (15). DWR is assisted by Groundwater Management Districts in western and south central Kansas. Together they work to formulate and enforce local policies concerning the conservation, management, and control of water within each district.

B. QUALITY REQUIREMENTS

The quality of the proposed water resource should be determined for both average and extreme conditions of flow and climate. Major sources of historical water quality data are available from the Kansas Water Data Base and STORET maintained by KDHE and EPA, respectively. In addition, KDHE requires that current water quality test results be submitted with permit applications for new sources (see Appendix B). The quality of a particular water resource must be compared with PWS water quality requirements to determine the most cost effective treatment for a specific water resource. Current PWS water quality requirements are contained in KAR 28-15-13, "Standards for bacteriological, chemical, physical, and radiological quality". Additional treatment requirements are specified in KAR 28-15-19, "Disinfection of drinking water", and KAR 28-15-21, "Surface water treatment rule." The designer must consider the worst conditions that may exist during the life of the facility.

C. SURFACE WATER - RESOURCE FACILITIES AND OTHER REQUIREMENTS

Surface water includes streams, rivers, impoundments, reservoirs, or other natural or man-made surface water sources. It can also include from a regulatory standpoint GWUI (see Chapter V, Section M on Disinfection). In this discussion, springs are considered surface water sources while all types of wells are considered groundwater sources even though they may be regulated as GWUI.

1. FLOWING SOURCES

a. STREAMS AND RIVERS - In selecting a location consider effects of confluent streams, navigation requirements, water depth, trash, ice, 100-year flood level, water velocity, channel changes due to sand mining or silting, eutrophication, separation from pollution sources, possibility of shoal or bar formation, water quality and effects due to changing meteorological condition, and access. Also evaluate quantity of supply, cost of development versus alternate locations and sources, and possible need for a storage dam, either in-channel or off-channel.

b. SPRINGS - Springs will be approved only after an extensive sanitary survey. The requirements for the protection of the spring will be determined by KDHE. Minimal requirements for springs include:

1) Documentation must be provided to confirm the absence of pollution sources. Either ownership or a perpetual easement must be obtained by the owner of the spring for the land within 100 ft (30.5 m) measured horizontally out from the spring. In either case, positive assurance is to be provided that no septic tanks, wastewater facilities, sanitary sewers, force main, or tile absorption fields will be allowed within that area.

The owner may use the land for agricultural or pasture purposes except that livestock must be kept at least 100 ft (30.5 m) away from the spring. Use of the land for any purpose shall not significantly contribute to pollution of the source water. Sanitary sewers to serve residential areas outside the 100 ft (30.5 m) wide protected zone shall transport the wastewater, either treated or untreated, to either a point downstream from the spring or to a separate watershed.

If the land area in question is owned by someone other than the owner of the PWSS, then a copy of a perpetual easement, detailing any limits or constraints on the use of the land by either party and showing the stamp of the Register of Deeds, must be submitted to KDHE. If the land is owned by the PWSS, then they

must provide a letter to KDHE which acknowledges the ownership. Where the land area in question is owned by the PWSS and other owners, then the ownership letter and perpetual easements must be submitted to KDHE for the appropriate areas of land. In all cases, the documents must indicate that no potential sources of pollution will be allowed within 100 ft (30.5 m) of the spring.

2) Springs located on a hillside or at the foot of a hill shall be avoided where sources of pollution are present on the slope above and within 300 ft (91 m) horizontally of the spring. An adequate intercepting ditch shall be constructed and maintained so as to keep hillside storm water at least 100 ft (30.5 m), measured horizontally, away from the spring.

3) Flood waters shall not approach closer than 100 ft (30.5 m) to prevent contamination of the spring.

4) Proper drainage in the vicinity of the spring shall be provided so as to prevent the accumulation of surface water, either by runoff or backflow, to within 100 ft (30.5 m) of the spring.

5) The intake structure and any pumping or water treatment facilities shall be enclosed in shelters which are weather and vandal resistant.

6) All water from springs shall be subjected to continuous disinfection and filtration as minimum treatment (See Section M, Disinfection, in Chapter V).

7) The spring area must be fenced to prevent unauthorized entry.

2. IMPOUNDMENTS

a. SITE SELECTION - Consider topography, catchment area, potential pollution sources, nutrient sources, watershed management, storage capacity versus dam and spillway required, geology, safety, and water rights. SCC administers several programs dealing with watersheds and water resources which involve sources of funding for water supply

development and improvement. A KWRRI study reviewed the impact of watershed management practices on the use of multipurpose reservoirs and lakes (16).

b. RAW WATER CHARACTERISTICS - Water quality variations for all conditions of stream flow should be considered.

c. PERMITS - A permit for controlling stream flow, placing a structure on the bed of any stream, or approval of a dam or spillway design must be obtained from DWR. DWR has established design guidelines for these structures and for related considerations (17).

d. LAKE USE - The designation of lakes as single purpose or multi-purpose will be made by the owners of the lake. SCC administers the Multipurpose Small Lakes Program for small flood control, water supply, and/or recreational projects (18). Recreational activities in or on any water used as a source of water supply must be conducted in such a manner that the water quality will not be adversely affected by these activities. Swimming is not recommended in any water supply impoundment except at designated sites.

3. EXISTING LAKES - No provisions for fish habitat enhancement in existing single purpose water supply lakes shall be permitted. Single purpose water supply lakes are those in which the owner has designated that the single use for the lake is for water supply purposes only.

Recreational and fish habitat enhancement activities in existing multipurpose lakes are permitted provided that compliance with drinking water quality standards is assured.

4. SINGLE PURPOSE LAKES - The following requirements must be met for water supply only lakes.

a. Site preparation for the lake shall include removal of trees and brush to the conservation pool elevation without major disturbance of the original surface area.

b. Either ownership or a perpetual easement must be obtained by the owner of the lake for the land within 200 ft (61 m) measured horizontally out from the high water level elevation according to the same procedures cited for springs in this chapter. In either case, positive assurance is to be provided that no septic tanks, wastewater facilities, sanitary sewers, force main, or tile absorption fields will be allowed within that area.

The owner may use the land for agricultural or pasture purposes except the livestock must be kept at least 15 ft (4.6 m) away from the high water level elevation by fencing. Use of the land for any purpose shall not significantly contribute to pollution of the source water. Sanitary sewers to serve residential areas outside the 200 ft (61 m) wide protected zone shall transport the wastewater, either treated or untreated, to either a point downstream from the lake or to a separate watershed. In all cases, the documents must indicate that no potential sources of pollution will be allowed within 200 ft (61 m) of the lake.

c. There shall be no upstream or direct discharges of untreated wastewater into the lake. Treated wastewater discharges must be approved by KDHE.

d. A program to control algal growths and minimize T&Os in the raw and/or treated water shall be carried out by the lake owner (see Part 7 on Copper Sulfate in Section N on T&O Control in Chapter V on Design of Water Treatment Processes). KDHE has published a report relating tastes and odor potentials in Kansas lakes to the trophic levels within the lakes (19).

e. A program for maintenance of shorelines and for control of aquatic weeds shall be carried out by the owner. It may be necessary at some time to lower the level of water in the lake so that woods and silt accumulations may be removed.

f. Other than for rock to be placed along bank lines for protection from erosion, no debris, trash, brush fish habitat enhancement structures, or other solid materials may be placed in the lake for any purpose.

g. During the planning process of the water supply lake, the consulting engineer shall evaluate the watershed area for potential pollutant or nutrient contribution and project the effect that it may have on the eutrophication rate and water quality. Where the effect can be interpreted as contributing to T&Os, drinking water quality standard violations, THM and/or turbidity problems, special attention to additional management of the lake watershed or to design of the treatment process will be required. KDHE and KWRRI reports review the impact watershed pollutants have on trihalomethane formation potential (20,21).

5. MULTIPURPOSE LAKES - For multipurpose lakes used primarily for public water supply purposes, the same requirements will apply as for single purpose lakes with the following exceptions:

   a. Trees and brush may be left standing in the conservation pool area. The location and the size of the area which may be covered by trees and brush shall be reviewed and approved by KDHE after consultation with KDWP on a case-by-case basis.

   b. Artificial fish enhancement substrates may be utilized. The location, type and size of the area which may be covered by such substrates shall be reviewed and approved by KDHE.

   c. The program established for treatment of the lake surface for algae control purposes is recommended rather than mandatory.

6. INTAKE STRUCTURES - Intake designs for streams, rivers, lakes, and reservoirs or other natural or manmade surface water sources shall be approved by KDHE. Approval by the COE or BOR is also required for federal reservoirs. Intakes requirements are:

   a. Reliable and sufficient capacity to supply treatment plant flow requirements for a 20 to 40 year design period under minimum head conditions.

   b. Locate in areas to avoid damage to aquatic life, not subject to excessive siltation or bank erosion, or not subject to receiving immediate runoff from sloughs and swamps. Protection shall be provided against surges, ice, floods, floating debris, boats, and barges.

c. A floating log boom or other effective device should be used around the intake structure. Screens and grates should be used to provide protection to pumps and treatment facilities, control the intake of debris and aquatic life, and should be self-cleaning.

d. Inlet flow velocities of 0.25 to 0.5 ft/sec (0.08 to 0.15 m/s) will minimize frazil ice problems. Control methods include the injection of steam into pump suction, and backflushing with settled water or use of air bubbler systems in front of gate openings.

e. Inlets or ports shall be located so that water may be admitted from a choice of depths to take advantage of favorable water quality. Their locations should be easily identified through permanent markers on the intake structures. A choice of at least three depths should be provided. Withdrawal of water from more than one level is desirable in run-of-the-stream intakes if the water quality varies with depth.

The lowest inlet or gateport should be placed at the elevation where it will be entirely submerged at all water stages yet not too close to the stream bottom where clogging occurs. Exposed or slightly submerged inlets should be avoided where potential navigational hazards exist. The lowest inlet location in a flowing source, lake or reservoir should consider future silt accumulations. Flowing source inlets are also affected by channel changes caused by scouring or sand mining.

In general, the velocity through the gross area of the inlets or ports should not exceed 1.0 ft/sec (0.3 m/s). Removable racks with 0.5 to 0.75 in (13 to 19 mm) metal bars to provide 1 to 3 in (25 to 76 mm) openings and velocities not to exceed 2 ft/sec (0.6 m/s) at maximum design flow through the opening should be used at the intake ports. Smaller debris can be removed using screens with 0.375 in (95 mm) or smaller openings and velocities similar to racks.

f. Inspection manholes should be located every 0 ft (305 m) for pipe sizes large enough to permit visual inspection and for occasional cleaning of

the inlet line. Conduit velocities should be 3 to 4 ft/sec (0.9 to 1.2 m/s) to avoid deposition of solids. Straight lines on a rising or falling grade should be used to avoid air accumulation. If this is not possible, air release provisions must be provided at the high points.

g. Shore shafts or pump wet wells provide storage for intake water at the design flow and minimum head conditions, adequate pump submergence, and surge capacity in the event of power failure. Fixed and traveling screens can be located in the shore shaft. Motors and electrical controls should be located above grade and protected from flooding. The shafts should be accessible, designed against flotation, have chemical addition points if necessary, valves for cleaning, testing of leaks, and backflushing where practical.

7. OFF-CHANNEL RESERVOIRS - This is a facility into which water is diverted during periods of high stream flow for future release to treatment facilities (or for low augmentation). Off-channel reservoirs shall be constructed to assure that the water quality is protected by controlling runoff into the reservoir, dikes are structurally sound and protected against wind action and erosion, and the point of influent flow is separated from the point of withdrawal.

D. GROUNDWATER - RESOURCE FACILITIES AND OTHER REQUIREMENTS

Groundwater sources include water from drilled, bored, or driven wells and infiltration lines, which are not under the direct influence of a surface water. Drilled wells are preferred. Springs are considered surface water sources (see part C. of this chapter). Sources most likely to be under the direct influence of surface waters (GWUI), include infiltration lines, radial water collectors, and shallow wells with screen openings less than 50 ft (15.2 m) deep and located within 200 ft (61 m) of a surface water. Under the SWTR, all GWUI must be treated like surface water (see Chapter V, Section M on Disinfection).

All water obtained from wells shall be disinfected and filtration may be needed (see Chapter V, Section M on Disinfection). The extent of water treatment required will be determined on the basis of geological data, well construction features, nearby sources of contamination, laboratory analyses, and MCLs. Where a well draws water from creviced

limestone strata and it is evident that the limestone supply is contaminated, use of this supply cannot be considered satisfactory unless it is properly treated by clarification and the elimination of harmful contaminants.

1. SANITARY SURVEYS - By means of a sanitary survey, the PWSS evaluates the potential threat to a proposed well presented by nearby sources of contamination. This allows the PWSS to estimate costs to reduce or contain threats to the proposed well by contaminant sources identified in the survey. Sanitary surveys made for selection of locations for wells should consider the following items:

   a. Character of local geology, size and topography of catchment area, and slope of ground surface, as such factors relate to the potential transport of contaminants toward the well.

   b. Nature of soil and underlying porous strata whether clay, sand, gravel, or rock (especially porous limestone); coarseness of sand or gravel, thickness of waterbearing stratum, depth to water table, location and log of wells in the vicinity that are in use and/or abandoned, as such factors relate to the potential transport of contaminants toward the well. Geologic data should be determined for new wells at 5 ft (1.5 m) intervals and at each pronounced change in formation along with other pertinent well drilling information. KGS maintains a Well Sample Library in Wichita.

   c. Slope of water table, preferably as determined from observation wells, or studies of wells in the area.

   d. Extent of drainage area likely to contribute water and potential contaminants to the supply, population of, and waste disposal methods in the drainage area.

   e. Susceptibility of the proposed well location to flooding from nearby surface waters as indicated by the boundaries of flood plain delineations or historical high water elevations.

   f. Nature, distance, and direction of potential local sources of pollution such as animal feedlots, sanitary landfills, seepage pits, cesspools, septic tank-lateral fields, privies sink holes, salt or brine supplies, test holes, abandoned wells,

borings, and chemical, manufacturing, handling, and storage facilities, including underground storage tanks and pipelines for industrial products, and industrial lagoons.

g. Special care should be taken to determine nitrate sources in the proposed well's recharge area and to evaluate fully the nitrate concentration in the aquifer in which the well will be completed. In addition to nitrate sampling of test holes in the immediate vicinity of the proposed public water supply well, other sources of information that should be considered include data from irrigation wells or other water supply wells in the general vicinity, KGS bulletins assessing geohydrology of the region, and data from the KDHE Groundwater Quality Monitoring Network. The nitrate level in the aquifer in which the well will be completed should be significantly less than the current nitrate MCL unless blending with other low nitrate wells is intended or treatment for nitrate removal will be provided.

2. LOCATION AND PROTECTION OF WELLS - Groundwater sources should be located, constructed, and maintained in a manner which will assure the minimum possibility of contamination and be so situated and developed as to prevent surface water from entering the well. During the installation of the well, the contractor shall provide protection to prevent tampering or accidental entrance of foreign materials. Specific siting limitations for new wells are the following:

a. There must be an absence of pollution sources within 100 ft (30.5 m) of the well. Documentation must be provided to confirm the absence of such sources. Either ownership or a perpetual easement must be obtained by the owner of the well for the land within 100 ft (30.5 m) measured horizontally out from the well center. In either case, positive assurance is to be provided that no septic tanks, wastewater facilities, sanitary sewers, force mains, or tile absorption fields will be allowed within that area.

The owner may use the land for agricultural or pasture purposes except that livestock must be kept at least 100 ft (30.5 m) away from the well. Use of the land for any purpose shall not significantly contribute to pollution of the source water. Sanitary sewers to serve residential areas outside

the 100 ft (30.5 m) wide protected zone shall transport the wastewater, either treated or untreated, to either a point downstream from the well or to a separate watershed.

If the land area in question is owned by someone other than the owner of the PWSS, then a copy of a perpetual easement, detailing any limits or constraints on the use of the land by either party and showing the stamp of the Register of Deeds, must be submitted to KDHE. If the land is owned by the PWSS, then they must provide a letter to KDHE which acknowledges the ownership. Where the land area in question is owned by the PWSS and other owners, then the ownership letter and perpetual easements must be submitted to KDHE for the appropriate areas of land. In all cases, the documents must indicate that no potential sources of pollution will be allowed within 100 ft (30.5 m) of the well.

b. Proper drainage in the vicinity of the well shall be provided so as to prevent the accumulation of surface water, either by runoff or backflow, to within 100 ft (30.5 m) of the well.

c. Wells located on a hillside or at the foot of a hill shall be avoided where sources of pollution are present on the slope above and within 300 ft (91 m) horizontally of the well. An adequate intercepting ditch shall be constructed and maintained so as to keep hillside storm water at least 100 ft (30.5 m), measured horizontally, away from the well.

d. The well shall not be located in a ravine where surface water flows may be obstructed or concentrated.

e. Shallow wells with screen openings less than 50 ft (15.2 m) deep shall not be located within 200 ft (61 m) of a surface water unless treatment will be provided that fully complies with all requirements applicable to groundwater sources under the influence of surface waters (see Chapter V, Section M on Disinfection). On a case by case basis, KDHE may approve the installation of such a well without the necessity of providing such treatment, upon submittal of a report by a qualified professional establishing that under the particular

hydrogeologic conditions, the proposed well will not be under the direct influence of any surface water.

f. The well vent on a pitless unit, or a vent in a well house or on a platform must be located at least 2 ft (0.6 m) above the 100 year flood level to prevent contamination by flood waters. If this level is not known, then the required elevation is at least 2 ft (0.6 m) above the highest known flood level.

3. CONSTRUCTION CRITERIA FOR WELLS - The following criteria should be followed in constructing a PWS well. Also, information about well abandonment is presented. Additional design requirements for pumps are presented in Chapter VII on Pumping Facilities.

a. CONTRACTOR LICENSING - Any water well contractor involved in the construction or reconstruction of any public water supply well shall possess a valid water well contractor's license, issued by the KDHE under the provisions of KAR 28-30-3. All contractors shall submit to KDHE a completed water well record form WWC-5 upon construction, reconstruction, or plugging of a public water supply well.

b. DRILLING FLUIDS, ADDITIVES, AND PACKERS

1) Drilling procedures or materials such as drilling fluids, additives, and packers shall not impart any T&O's, toxic substances, bacterial contamination, or any other regulated water quality contaminant to the well installation or the aquifer, itself.

2) Water used for drilling fluids shall be from a fresh, nonpolluted source. Only drilling fluids which do not plug the aquifer should be used. The use of organic drilling fluids, such as formed through the addition of polymeric additives, have the potential for enhancing biological activity within the aquifer and are not approved.

3) When additives to the drilling fluid are used, drilling-fluid properties shall be maintained within limits that will allow the additives' complete removal from the well and not damage the potential capacity, efficiency, or quality of the well.

c. TEMPORARY SEALING REQUIREMENTS

1) During construction, a temporary means of sealing the well shall be provided to prevent debris or any contaminants from entering the well or annular space.

2) Wells in which no pump is installed shall be securely sealed until setting of the pump or plugging of the well upon abandonment.

3) A welded metal plate or a threaded cap is the preferred method for temporary sealing of a well.

d. WELL CASING

1) All wells shall have durable watertight casing from at least one foot (0.3 m) above finished ground surface to the top of the producing zone of the aquifer. The casing shall extend at least 20 ft (6.1 m) below the ground level.

2) All casing material shall be new and conform to the types, manufacturing standards, and minimum diameter requirements specified in AWWA Standard A100 (4). Minimum wall thickness requirements for steel well casing shall conform to AWWA Standard A100 (4). Minimum wall thickness requirements for thermoplastic well casing shall conform to ASTM F480 (22).

3) Joints should be watertight and of the type specified in AWWA Standard A100 (4).

4) The casing shall extend not less than 12 in (0.30 m) above the top of the well house floor. No casing shall be cut off below the ground surface except to install a pitless unit.

5) The casing should be provided with sufficient guides welded to the casing to permit unobstructed flow and uniform thickness of grout.

6) The top of the well casing shall be sealed by installing a sanitary well seal.

e. WELL SCREEN

1) The well screen serves as the intake section of a water supply well, allowing the passage of water from an aquifer in unconsolidated formations such as sand and gravel. The screen also provides structural support for the surrounding formation. The screen should be designed to promote the free flow of water into the well pump area while preventing the entrance of sand.

2) The screen aperture size should be designed to retain a certain specified percentage of the formation material for naturally developed wells or gravel-pack material for gravel-packed wells as determined by accepted well design practices and site specific conditions.

3) The entrance velocity into the screen should not exceed 0.1 ft/sec (0.03 m/s) based on the maximum anticipated well flow rate or yield as determined by the following formula:

$$V_e = \frac{Q}{7.48 A_e L}$$

Where:

V_e = entrance velocity (ft/min)
Q = maximum well flow rate or yield (gpm)
A_e = effective aperture area per foot of screen (ft^2/ft). The effective aperture area shall be taken as one half of the total aperture area per foot of screen to allow for clogging of slots.
L = length of screen (ft)

KDHE will approve entrance velocities that exceed the 0.1 ft/sec (0.03 m/s) limit upon a showing that higher velocities will not impair the integrity of the well screen or result in excessive head loss.

4) Screen length should be determined by the thickness and hydrologic character of the aquifer, in conjunction with the determination of screen aperture size.

5) In some applications, other considerations such as approach velocities, turbulent versus laminar flow, and velocity distributions into the screen and through the aquifer, may require variance from the above screen design criteria.

6) The material from which the screen is fabricated shall be corrosion resistant and not susceptible to damage by chemical action of groundwater or cleaning operations.

7) Joints between screen sections and blank casing spacers should be welded or threaded, watertight, straight, and as strong as the screen.

8) Guides should be placed above and below all screen sections to hold the screen in the center of the borehole.

f. GRAVEL PACK

1) Gravel pack is installed in the annular space between the screen (and casing) and bore hole for the purpose of stabilizing the formation.

2) Gravel pack should consist of smooth, well rounded particles, at least 95 percent siliceous material with an average specific gravity of not less than 2.5. Before placement, the gravel pack should be washed and free of shale, mica, clay, dirt, loam, and organic impurities of any kind, and contain no iron or manganese in a form or quantity that will adversely affect the water quality.

3) Gravel-pack design should be based on the ratio of the grain size of the gravel pack to the formation material and sized to stabilize the native formation and yet allow water to be produced from it as determined by accepted well design practices and site specific conditions. The gradation of the gravel pack should be selected after test hole samples of the formation material to be screened have been sieved and analyzed pursuant to ASTM C136 (22).

4) The gravel pack should be placed in a continuous layer of material surrounding the entire screen without bridging or voids and extend above the screen to a height sufficient to compensate for potential settlement of the gravel pack during well development and provide a sufficient buffer between the well intake and the annular seal above. The minimum thickness of the gravel pack to allow for proper placement of the gravel-pack material in the annulus around the screen is 4 in (10.2 cm).

5) Before placement in the well annulus, the gravel-pack material shall be disinfected by immersing the gravel in a chlorine solution containing not less than 200 mg/L of available chlorine.

6) The installation of gravel refill pipes are approved by KDHE where excessive loss of gravel-pack material is anticipated to occur due to formation conditions. Gravel refill pipes shall be Schedule 40 steel and located in the grouted annular opening of the well, surrounded by a minimum of 1.5 in (3.8 cm) of grout. The pipes shall be incorporated within the pump foundation, and extend at least 12 in (0.3 m) above the pump house floor or concrete apron. To prevent contamination of the well, the gravel refill pipe shall be provided with a secure, access lid or cap, designed to completely cover the opening of the pipe and provide a watertight seal.

g. GROUTING OF ANNULAR SPACE BETWEEN THE CASING AND DRILL HOLE

1) Wells shall be sealed by grouting the annular space between the casing and the well bore from ground level to a minimum of 20 ft (6.1 m) or to a minimum of 5 ft (1.5 m) into the first clay or shale layer, if present, whichever is greater. If a pitless well unit is being installed, the grouting shall start below the junction of the pitless well unit where it attaches to the well casing and shall continue a minimum of 20 ft (6.1 m) below this junction or to a minimum of 5 ft (1.5 m) into the first clay or shale layer, if present, whichever is greater.

2) To facilitate grouting, the grouted interval of the well bore shall be drilled to a minimum diameter at least 3 in (7.6 cm) greater than the maximum outside diameter of the well casing. If a pitless well unit is being installed on the well's casing, the well bore shall be a minimum diameter of at least 3 in (7.6 cm) greater than the outside maximum diameter of the well casing through the grouted interval below the junction of the pitless well unit where it attaches to the well casing.

3) Protection from leakage of grout into the gravel pack or well screen shall be provided.

4) Waters from two or more separate aquifers shall be separated from each other in the bore hole by sealing the bore hole between the aquifers with grout or other material specifically approved by KDHE.

5) If a dummy casing is to be retained, the annular space between a dummy and well casing shall be filled with grout having a minimum thickness 1.5 in (3.8 cm) to a minimum depth of 20 ft (6.1 m). In addition, the annular space between the dummy casing and well bore shall be grouted as specified in this chapter.

6) Sand-cement grout or neat cement grout shall be used for grouting the annular space from ground level to 20 ft (6.1 m) below the surface, or, if a pitless well unit is being installed, from the junction of the pitless well unit with the well casing to 20 ft (6.1 m) below the unit.

   a) "Sand-cement grout" means a mixture consisting of one 94 lb (42.6 kg) bag of portland cement (ASTM C150) to an equal volume of sand having a diameter no larger than 0.080 in (2 mm) to 5 to 6 gal (18.9 to 22.7 L) of water.

   b) "Neat cement grout" means a mixture consisting of one 94 lb (42.6 kg) bag of portland cement (ASTM C150) to 5 to 6 gal

(18.9 to 22.7 L) of water. A maximum of 5 percent, by weight, bentonite may be added. Other additives may be used only with KDHE approval.

c) Water used to mix cement grout should be clean, fresh water, free of oil or other organic material, and with a total dissolved mineral content less than 2,000 parts per million. A water with a high sulfate content should be avoided.

d) Care should be exercised to control the heat of hydration during grouting where thermoplastic well casing has been installed. Additives that tend to significantly increase the heat of hydration are not recommended.

7) For PWS wells, KDHE does not recommend the use of annular seals consisting solely of bentonite clay grouts because of concern whether bentonite seals have sufficient shear strength to resist hydrostatic forces in certain aquifer systems. Bentonite clay grouts are approved for grouting the annular space in a well for depths greater than 20 ft (6.1 m) from the surface (or greater than 20 ft (6.1 m) below the junction of a pitless well unit with the well casing), where the initial 20-foot (6.1-meter) length of annular space will be sealed with a sand-cement or neat cement grout.

a) "Bentonite clay grout" means a mixture consisting of water and commercial grouting sodium bentonite clay as per the manufacturer's recommendations to achieve a weight of not less than 9.4 lb (4.3 kg) of bentonite clay per gal (3.8 L) of mix. Weighing agents may be added as per the manufacturer's recommendations.

b) Sodium bentonite pellets, tablets, chips, or other granular sodium bentonite are acceptable as an annular seal at depths greater than 20 ft (6.1 m) provided the material can be installed without bridging or voids and it meets the 9.4 lb (4.3 kg) of bentonite clay per gal (3.8 L) mix requirement.

c) Sodium bentonite products that contain low solids, are designed for drilling purposes, or that contain organic polymers shall not be utilized for grouting the annular space of a well.

h. PLUMBNESS AND ALIGNMENT REQUIREMENTS

1) The completed well shall be sufficiently plum and straight so that there will be no interference with the installation, alignment, operation, or future removal of the permanent well pump.

2) Every well should be tested for plumbness and alignment.

3) The test method for plumbness and alignment and allowable tolerance shall be clearly stated in the construction specifications for the well.

i. DEVELOPMENT

1) Every well shall be developed to remove the native silts and clays, drilling mud, or finer fraction of the gravel pack.

2) The construction specifications for the well shall provide for the application of appropriate well development techniques for the optimization of well efficiency and specific capacity. The specifications should further define criteria for determining satisfactory completion of well development. In general, development should continue until the optimum specific capacity is obtained from the completed well. Additional criteria for determining completion of well development may include a limit on sand content. If so, a method for measuring sand content should be specified.

3) Records of all development work should be maintained including measurements of key parameters at appropriate time intervals such as static and pumping water levels, production rates, specific capacity, sand content, specific conductance, temperature, etc.

4) Where chemical conditioning is required, the construction specifications for the well shall include provisions for the method, equipment, chemicals, testing for residual chemicals, and disposal of waste and inhibitors.

j. WELL CAPACITY TESTS

1) Yield and drawdown tests shall be performed on every public water supply well prior to placement of the permanent pump in order to verify the pumping rate and the capability of the well and aquifer to maintain this production level. The test methods and data reporting requirements shall be clearly described in the construction specifications for the well.

2) Well capacity tests should be conducted only after development of the well has been completed satisfactorily.

3) During the tests, the discharge of the pump shall be conducted either by pipeline or lined channel beyond the potential zone of influence of the well.

4) A constant-discharge test should be conducted consisting of continuous pumping of the supply well at a rate at least as high as the long-term production rate to be required from the well. Water-level measurements should be obtained before, during, and after the pumping test in order to determine the static water levels, to evaluate the effect of pumping, and to determine a profile of the recovery of the water level from the pumping state to the original, static level. The measurement frequency of water levels during pumping should be such that an adequate delineation of the time-drawdown data is obtained. Additional tests such as step drawdown are recommended.

k. DISINFECTION - KDHE procedures for disinfecting gravel packed wells and completed wells, whether new, modified, or reconditioned, are as follows:

1) All drilling waters used during the construction or reconstruction of any water

well shall be initially disinfected by mixing with the water enough sodium hypochlorite to produce at least 200 mg/L of available chlorine.

2) Gravel for gravel-packed wells shall be disinfected prior to placement by immersing the gravel in a chlorine solution containing not less than 200 mg/L of available chlorine. A satis-factory solution may be made by mixing about 5 oz (140 g) of high test calcium hypochlorite (65 - percent available chlorine) with 100 gal (380 L) of water.

3) Completed wells, after development, shall be disinfected by adding sufficient hypochlorite solution to produce a con-centration of not less than 100 mg/L of available chlorine when mixed with the water in the well. This corresponds to the use of about 1.5 lb (0.68 kg) of high test calcium hypochlorite (65 percent available chlorine) per 1,000 gal (3,785 L) of water in the well.

4) Just prior to setting, the pump and the pump column shall be washed down with a 200 mg/L available chlorine solution.

1. ABANDONED WELLS AND TEST HOLES - Before any well or test hole drilled in connection with a water supply is abandoned, it shall be plugged in such a manner as to prevent the pollution of the groundwater by contaminating substances. Abandoned water wells and test holes shall, whether cased or uncased, be plugged in accordance with the requirements of KAR 28-30-7.

4. CONSTRUCTION CRITERIA FOR WELL HOUSES, DISCHARGE PIPING, AND RELATED APPURTENANCES - The following criteria must be followed in constructing a well house. In addition, criteria for discharge piping and appurtenances is presented. Additional design requirements for pumps are presented in Chapter VII on Pumping Facilities.

a. GENERAL WELL HOUSE REQUIREMENTS

1) The well house shall be provided with a doorway and a door at least 2 ft 8 in (0.8 m) by 6 ft 8 in (2.0 m) which opens outward and extends to the floor. The door shall be equipped with a lock.

2) Well houses located on hill slopes shall have not less than 50 percent of the floor area above ground level and the door located on that part of the floor above ground level.

3) The well house walls and ceiling shall be insulated.

4) Where necessary, additional protection against freezing shall be provided by installing a thermostatically controlled electric heater or other suitable type of heating unit.

b. WELL HOUSE FLOOR

1) The well house floor elevation shall accommodate the well vent elevation requirement that the vent be located at least 2 ft (0.6 m) above the 100 year flood level. It this level is not known, then the required vent elevation is at least 2 ft (0.6 m) above the highest known flood level.

2) The top of the floor slab shall not be less than 1.5 ft (46 cm) above the natural ground.

3) The well house floor shall be constructed of reinforced, water tight concrete not less than 4 in (102 mm) thick at any point.

4) The joint between the concrete pump base and floor shall be water tight. The pump base shall be extended to natural ground to provide solid support.

5) The floor shall extend not less than 3 ft (0.9 m) in all directions from the outer edge of the drill hole.

6) The floor slab shall rest upon thoroughly compacted earth or upon a protected settled sand fill.

7) The floor shall slope at a rate of 1/8 ipf (1.0 cm/m) toward the floor drain.

c. FLOOR DRAIN

1) A minimum 4 in (102 mm) floor drain with a perforation or screened cover shall be provided.

2) The drain pipe shall carry the drain water to the ground surface at least 20 ft (6.1 m) from the well or at least 4 ft (1 m) from the well house wall at which point the pipe may be connected to other suitable 4 in (102 mm) pipe so that the drainage will be carried to the ground surface at least 20 ft (6.1 m) from the well.

3) The drain pipe shall be laid on a grade of not less than 1/8 ipf (1.04 cm/m) and shall discharge onto the surface of the ground. The drain shall not be connected to any storm drain, sanitary sewer, or any other closed conduit. The discharge end of the drain line should be covered with a coarse non-corrodible screen to prevent the entrance of small animals.

d. CASING SEAL AND DISCHARGE PIPING

1) The casing shall extend at least 1 in (2.5 cm) into the pump base plate so as to form an overlapping seal. On flat pump base plates and on other base plates where radial ribs interfere, a metal skirt projecting downward may be welded to the outside edge of the base plate to form the overlapping cover for the well casing.

2) The metal pump base plate shall be grouted and bolted or otherwise securely sealed to the concrete base so as to be watertight.

3) The discharge line, and meter, check and shutoff valves shall be located above the well house floor.

e. WELL VENT

1) The vent shall be constructed of metal tubing or pipe and fitted through the pump base so as to form a watertight connection with the base.

2) The vent shall terminate in a full 180° return bend not less than 2 ft (0.6 m) above the pump base.

3) The opening in the vent shall be screened with 16-mesh non-corrodible screen.

f. WATER LEVEL MEASUREMENT

1) Provisions shall be made for the periodic measurement of water levels in the completed well in accordance with specifications of DWR (23). The following water level measurement methods are approved for public water supply wells:

a) Air line method,
b) Separate observation well within 25 ft (7.62 m) of the production well, or
c) Electronic water level measurement sensors.

A separate tube installed outside the casing for use of a tapeline drawdown measurement is prohibited.

2) Air line method - The air line method measures depth to water level by determining the air pressure required to push water out of a submerged tube of known length. The air line tube shall be constructed of corrosion-resistant materials and pass through the pump base inside the well casing in a manner that will provide for a watertight seal between the pipe and the pump base, i.e., a watertight packing gland or equal shall be provided around the pipe where it passes through the pump base. To avoid turbulence near the intake of the pump, the lower end of the air line should be several feet above or below the point where water enters the pump but still extend below the lowest possible pumping level. The upper end of the tube is fitted with suitable connections for an air gauge, valve, and air pump. The actual installed length of air line shall be indicated on a metal plate in the immediate vicinity of the well.

g. VALVES AND OTHER APPURTENANCES

1) The pump discharge line shall be equipped with a check valve, shutoff valve, and a standard pressure gauge.

2) Air/vacuum relief valves - Combination air and vacuum relief valves may be required where air is forced into the pump discharge line through the pump resulting in decreased efficiency and possibility of surges within the lines. These valves are potential sources of contamination to the water supply because contaminants can be drawn into the water supply on the vacuum relief cycle.

The vent discharge lines from air/vacuum relief valves on pump discharge lines should terminate in a downward position about 2 ft (0.6 m) above the floor of the well house. If splashing is a problem, a loose fitting "splash guard" may be used. The end of the vent discharge line should be screened with 16-mesh noncorrodible screen. In no case should the vent discharge line be tightly connected to the floor drain. Air/vacuum relief values on pump discharge lines should be located on the pump side of the check valve and meter.

3) Meters - Meters shall be provided for all wells. Meters shall meet the specifications of DWR (24). Meters should be located on the pump discharge line and on the pump side of a shutoff valve but after the air/vacuum release valve and check valve.

4) Sampling tap - A sampling tap is required on the discharge side of the pump and after the point of chlorine application to obtain samples for measurement of chlorine residual (or other necessary measurements). A distance of at least 10 ft (3.0 m) should be maintained between the point in the discharge piping where the chlorine solution is applied and the location of the sampling tap. The piping layout in most well houses does not provide this much distance, therefore, the sampling line extends back into the well house. It is desirable to provide a gate valve in the sampling line ahead of the tap or hose bib so that the tap can be repaired or replaced without depressurizing a portion of the distribution system.

5. CONSTRUCTION CRITERIA FOR PITLESS UNITS AND RELATED APPURTENANCES

a. APPROVAL CRITERIA - The use of pitless units for public water supply wells for below-ground discharge is approved. Pitless "adapters" are not approved for this purpose. A pitless unit is one which has been manufactured as a complete unit specifically for attaching to the well casing at a point below frostline to form a continuous, unbroken extension of the casing to at least 12 in above the finished ground surface.

The unit may be for either submersible pumps or for deep well type turbine pumps and must permit the pumps to be readily removed. The unit material of construction shall be compatible with the casing. The inside diameter should equal that of the casing up to and including diameters of 12 in (0.3 m) to facilitate repair work on the well, pump, or well screen. KDHE approval is required for any connections where the pitless diameter is different from the casing. The water delivery pipe shall be attached below frost level by a threaded fitting.

b. LIMITATIONS ON FIELD WELDING - If the connection to the casing is by field welding, the shop-assembled unit must be designed specifically for field welding to the casing. The only field welding permitted will be that needed to connect a pitless unit to the casing and must be a continuous weld.

c. CONCRETE SLAB - In lieu of a well house, a reinforced concrete slab not less than 4 in (10 cm) in thickness and extending 3 ft (0.9 m) beyond the well drill hole in all directions shall be provided. The slab shall form a watertight joint with the pitless unit.

The slab should preferably be placed at the ground finish grade, 1.5 ft (0.46 m) minimum above the natural ground, and shall slope away from the casing. The concrete slab shall be designed and constructed to withstand alternating freezing and thawing conditions. Approval may be given for placement of the slab below the pitless unit and below ground level. Where a pitless unit is used, a protective railing or steel posts shall be provided in such a manner that the pitless unit may not be damaged by machinery or farm animals.

d. APPURTENANCES

1) Check valve - There shall be at least one check valve within the well casing.

2) Sanitary well seal - The top of the pitless unit shall be securely fitted with a sanitary well seal, which creates an air and watertight seal. The pitless unit shall also be adapted to receive a contamination-proof conduit for power purposes.

3) Well vent - The pitless unit shall be fitted with a vent, which shall terminate in a full 180° return bend. The elevation of the well vent shall be not less than 2 ft (0.6 m) above the 100 year flood level. If this level is not known, then the required vent elevation is at least 2 ft (0.6 m) above the highest known flood level. The opening in the vent shall be screened with 16-mesh non-corrodible screen.

4) Water level measurement - Provisions shall be made for the periodic measurement of water levels in the completed well in accordance with specifications of DWR (23). Tubes or cables, required for measurement of water levels, shall be installed through special fittings in the watertight cap in a manner to prevent the entrance of surface water or other contaminants within the well casing.

5) Meter - Each well must be provided with a meter as specified by DWR (24). Meter boxes or vaults should be constructed with crushed rock bottoms (French drains) to permit drainage and located and covered so as to minimize the entrance of surface water. A shut-off valve should be located downstream from the meter.

6) Sampling tap - A means should be provided to collect water samples from the well or discharge piping.